NRRC
Natural Resources Research Center

USDA
Object Modeling System (OMS)
Strategic Plan

Executive Summary

The Object Modeling System (OMS) provides an automated framework for building, testing, validating, certifying, and deploying science components and models to support the delivery of USDA programs and technical assistance to agricultural producers and natural resource managers. The framework saves time, reduces cost, facilitates continuity, and helps agencies coordinate resources to apply best science to program initiatives. OMS promotes collaboration to speed technology transfer from research to program delivery agency. It takes advantage of recent advancements in the information technology (IT) field to remove burden and free the modeler to focus on the science. The framework deploys science models as services on a platform easily accessible to business applications.

The USDA Agricultural Research Service (ARS) developed OMS at the Agricultural Systems Research Unit (ASRU) in Fort Collins. Development partners included ARS, USDA Natural Resources Conservation Service (NRCS), Colorado State University (CSU) Department of Civil and Environmental Engineering, and U.S. Geological Survey (USGS). In early 2008 through a Memorandum of Understanding (MOU), ARS transferred the system to NRCS, which agreed to maintain it at its Information Technology Center in Fort Collins. Currently, OMS supports five modeling projects concerned with conservation effects assessment, water supply forecasting, erosion prediction, engineering practice design, and forage growth and utilization. OMS has become the de facto modeling framework for USDA.

The OMS Strategic Plan sets forth four goals and accompanying objectives.

Goal 1 – The USDA agro-environmental modeling portfolio expands to meet priority business needs.

Objective 1 – Develop core model bases each for (1) farm/field level decision support, (2) farm/field level practice design, (3) seasonal natural resource forecasting, (4) basin/watershed assessment, and (5) ecosystem services determination.

Objective 2 – Build a robust data provisioning service for the model bases in OMS.

Objective 3 – Create knowledge bases to facilitate understanding the relationships among OMS models and their components, and to facilitate the interaction of computational and non-computational knowledge.

Objective 4 – Develop and support a cadre of OMS modelers

Goal 2 – Agro-environmental model use increases to become ubiquitous at the field and watershed scales in the country.

Objective 1 – Deploy OMS models as registered advertised services to run on an elastic computing cloud platform.

Objective 2 – Enable multi-threaded model runs on the production platform.

Objective 3 – Calibrate and validate OMS models by physiographic regions in a coordinated and consistent manner.

Objective 4 – Develop and deploy data access services in the OMS computing cloud.

Goal 3 – USDA scientists develop models in OMS and apply them to synthesize research results across locations and extend them to multiple weather and soil conditions on a regional scale.

Objective 1 – Establish policies to promote the use of OMS to integrate systems modeling with field research.

Objective 2 – Develop consistent state-of-the-science research models for priority problem areas.

Objective 3 – Facilitate collaborative modeling and delivery of science models and components to USDA program delivery agencies.

Goal 4 – Agro-environmental models and components are deployed and used across frameworks facilitating collaborations between USDA and external partners.

Objective 1 – Create and apply a non-invasive model development standard.

Objective 2 – Establish OMS as an open source community modeling system with appropriate governance.

Objective 3 – Develop collaborations and relate OMS with other major modeling groups and frameworks.

The strategic plan also describes the USDA business cases for model services, discusses the current and future architecture and concept of operations, and summarizes resources to sustain the system lifecycle. The plan should be considered a working draft through 2009 while it is vetted through USDA and partner organizations and interests. OMS replaces legacy methods for modeling and technology transfer, with the most significant adjustment likely focused organizing resources for data provisioning and model validation support.

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Contact Information

Information Technology Center (ITC)
USDA Natural Resources Conservation Service
Natural Resources Research Center
2150 Centre Avenue, Building A
Fort Collins, Colorado 80526

Frank Geter, Acting Business Systems Development Branch Chief
Ken Rojas, OMS Project Manager
Jason Restad, Lead Application Architect
David Butler, Lead Data Architect
Daniel Meyer, Science and Technology Liaison

Agricultural Systems Research Unit (ASRU)
USDA Agricultural Research Service
Natural Resources Research Center
2150 Centre Avenue, Building D
Fort Collins, Colorado 80526

Laj Ahuja, Research Leader
James Ascough II, Research Scientist
Timothy Green, Research Scientist
Jack Carlson, Collaborator

Department of Civil and Environmental Engineering
Colorado State University
Fort Collins, Colorado 80523

Luis Garcia, Department Head
Olaf David, Lead OMS Architect (ASRU address)
George Leavesley, Research Associate (ASRU address)
Wes Lloyd, Research Associate (ASRU address)

Strategic Plan
For the USDA Object Modeling System (OMS)

Introduction

The Object Modeling System (OMS) is a modeling framework of the U.S. Department of Agriculture (USDA), maintained by the Natural Resources Conservation Service (NRCS) with support from the Agricultural Research Service (ARS) and Colorado State University (CSU). The framework provides scientists a consistent and efficient way to create science components, build models, calibrate and test them, and modify and re-purpose them as the science advances. The framework also enables the user to run models in support of action agency program delivery. OMS is an important part of the USDA technical architecture supporting technology transfer from research to program delivery agencies. The current emphasis is on agro-environmental modeling.

USDA research benefits the operators of approximately 2.1 million farms, ranches, and small woodlands, who make daily decisions to manage a combined 1.1 billion acres of private land. Federal and state conservation programs deliver technical and financial assistance to help operators sustain the health of the land and maintain its productivity over the long term. Federal programs deliver about $3 billion annually to partially defray the cost of installing and maintaining practices contained in the operators conservation plan. These practices reduce erosion, promote soil health, optimize nutrient management, control pesticide leaching and run-off, and prevent overgrazing to sustain food and fiber productivity. They also improve wildlife habitat, and provide other ecosystem services.

USDA research also supports several thousand agricultural and environmental consultants, who advise land managers and producers in optimizing productivity in a sustainable and environmentally sound manner.

USDA manages the public land National Forest System through the Forest Service. Ranger district managers across approximately 700 offices make daily decisions affecting the production, use, and sustainability of 192 million acres of forest and grassland. Forest Service research and technology development also benefits state and private forestry programs, and the forest products industry.

OMS fills the strong business need to deliver the best science and technology to these decision makers and their advisors in as efficient and responsive manner as possible. It provides the technology bridge to the information systems that support the decision making process.

History

The practical need for a modeling framework was first recognized in the 1980s as models were developed at several locations across USDA. Various meetings addressed requirements for building models in a modular fashion using agreed upon standard and conventions. The Terrestrial Ecosystems Regional Research and Analysis (TERRA) project in the early 1990s, involving USDA, the Department of Interior, and several non-federal institutions and organizations, embraced work by the U.S. Geological Survey (USGS) on a Modular Modeling System (MMS). The OMS project began in 1996 at the Friedrich Schiller University of Jena in Germany. ARS hosted a workshop in 1997 to develop strategies for coordinated, collaborative modeling approaches based on modular techniques. In October 2000, ARS, USGS, and NRCS formed a project to continue development of OMS and adapt it for technology transfer in the United States, evolving the MMS concept (Leavesley et al 1996) to a platform supporting object oriented component design and programming (Ahuja et al 2004).

OMS initially was developed as a custom application in Java 1.3 and XML (Extensible Markup Language) using the Java Swing widget toolkit. It contained a component builder, component repository, model builder, metadata dictionary, and user interface for model development and operation. The OMS Swing version was considered a prototype, and starting in 2002, OMS was re-factored and migrated to the Java Netbeans integrated development environment (IDE) platform. In April 2004, the ARS Administrator presented OMS 1.0 to NRCS in a hand-off ceremony at Fort Collins, Colorado. The Precipitation Runoff Modeling System (PRMS) and Root Zone Water Quality Model (RZWQM) were the test models to build and release the framework (Ahuja et al 2004). The initial repository contained components from these models.

OMS subsequently was updated to version 1.1 by the end of 2004 and 1.2 in 2005 as features were added to the framework. USDA scientists used the framework to model erosion and forage growth processes (Flanagan et al, 2005; Andales et al, 2005).

In 2006, OMS 2.0 included a significant Netbeans upgrade and the model execution API (Application Programming Interface). During 2007, more features were added to version 2.1 to support modeling efforts for water supply forecasting and the Conservation Effects Assessment Project (CEAP).

In September, 2007 an expert panel of members from ARS, USGS, National Oceanic and Atmospheric Agency (NOAA), Environmental Protection Agency (EPA), and National Aeronautics and Space Administration (NASA) reviewed the OMS project and made recommendations for sustaining and improving the framework. The panel recommended developing a concept of operations, upgrading system and user documentation, establishing a liaison to work with the modeling community, applying more detailed project management, expanding the model and component repository around business needs, and finding the requisite resources to do this work.

In February 2008, the ARS administrator presented OMS version 2.1 to the NRCS Chief in a hand-off ceremony at Washington, DC, and both signed a Memorandum of Understanding (MOU) containing the responsibilities and duties for maintaining the modeling framework over the long term. The MOU is included as Appendix I to this plan.

During 2008, OMS 2.2 added more to support the on-going modeling projects. More detailed information on the history of the OMS lifecycle is found under Documents at http://oms.javaforge.com, in a file named OMSWS.ppt. A graphical description of the current system is displayed in Figure 1.

As of January 2009, the OMS repository (called the OMS Component Library) contains approximately 200 model components contributed by the PRMS, CEAP (primarily the J2Ks model), Wind and Water Erosion Model (WWEM), and iFarm-Forage modeling efforts. In addition, a large set of soil parameter components were developed for the library. The components are listed in Appendix II.

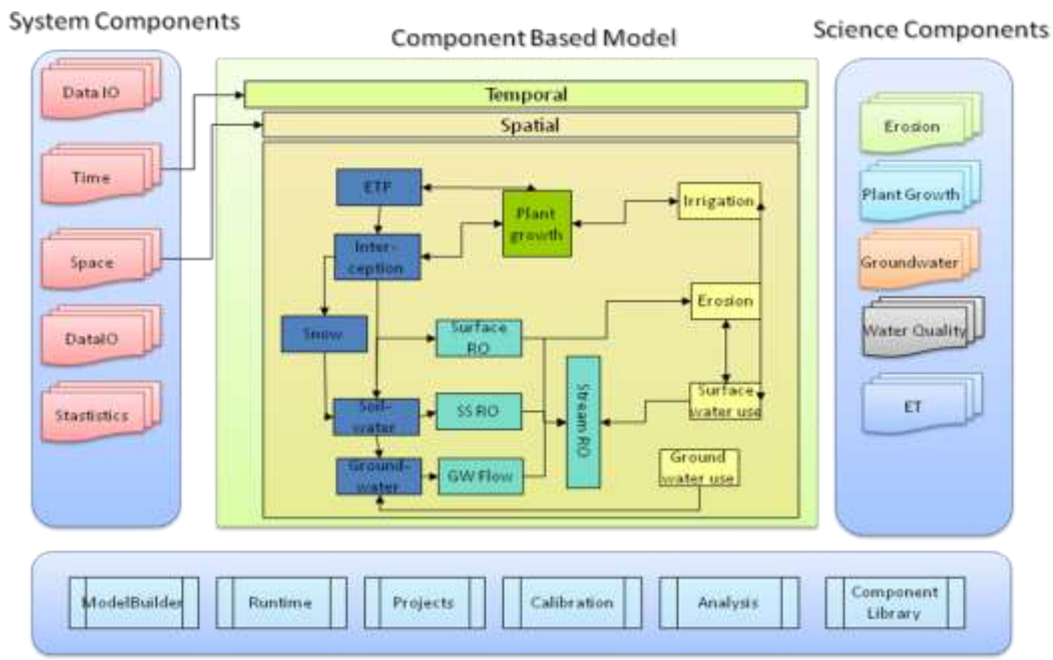

Figure 1. The features of OMS 2.2 as of January 2009.

Justification for the USDA Object Modeling System

OMS provides a standard platform to build and manage components and models supporting the business interests and mission of USDA. The concept for the platform includes deploying models as services in a production environment for integration with agency business applications. The platform provides data provisioning to models with linkages to data provider collection and management infrastructure. OMS provides non-science system components modelers otherwise would have to code themselves as overhead in a do-nothing alternative.

The driving factors for adopting the OMS modeling framework are (1) saving time, (2) reducing cost, (3) assuring quality, (4) ensuring maintainability, and (5) aligning solutions to business needs. Using OMS enables the modeler to focus on the science, re-use previously developed and certified components, exchange components with peers, obtain professional credit, and build models and regional variations quickly. OMS provides the organization using the model a consistent platform for provisioning data and running simulations to analyze and develop solutions in business applications. OMS provides a bridge to transfer technology from research to action agencies and organizations efficiently. The certification and adoption of new science and technology is made easier.

Alternatives to the OMS platform would include adopting one of the existing frameworks outside of USDA, which are discussed later this document. To this point, most frameworks impose API dependencies on the components and models. These frameworks therefore are called invasive. USDA models and components would be vulnerable and subject to considerable re-work in the event a non-USDA framework lost support. A recent comparison shows OMS less invasive than most frameworks, and the next generation OMS will remove API dependencies.

OMS is open-source, written in Java, and platform independent. While it currently supports wrapping legacy model code in FORTRAN and other languages, emphasis will be put on creating models and components in Java using industry standard coding conventions, focused on USDA business needs. OMS currently requires the Netbeans IDE (Integrated Development Environment), but likely will run with Eclipse and other Java IDEs in the future. Next generation OMS also will support Java Native Access (JNA), enabling OMS models to contain components compiled in other languages. For example, a Java OMS model would use JNA to run an erosion estimator component coded in C++ and compiled as a DLL (dynamic-link library).

Several frameworks focus on re-purposing separate legacy models by linking them together and provisioning data to them to address a particular business need. However, most legacy code of interest to USDA has become too difficult to maintain and improve going forward. Further, legacy models contain considerable redundancy in component functionality. Legacy models built many years ago also are not optimized for high performance computing and heavy user loads. Therefore emphasis will be placed on building new components and models in Java.

Redundancy across legacy models also argues for consolidation and simplification to a small number of model families, or what are termed model bases. Models tend to proliferate, and instead of tens or hundreds of separately supported stovepipe models, science components should be aggregated into models, and related model instances into a model base. USDA probably needs less than 10 model bases to support business needs across its agencies.

Definitions

Agro-Environmental – Pertaining to agricultural and environmental resources

Component – Software unit that encapsulates data and operations to realize one specific purpose, communicates through a defined interface, exhibits “black box” behavior, and is testable.

Compound Component – Software unit containing two or more components; a compound component can contain other compound components; a model can be understood to be a compound component.

Computing Cloud – Virtual computing infrastructure and capacity delivered as a service, often by a large commercial data center provider; the customer configures virtual instances of servers, storage, and network devices scaled the processing requirements of the application to be deployed in the cloud.

Data Provisioning – The compilation, processing, packaging, and delivery of data to support the development and use of models. Includes standard reference data (state/county/country codes, hydrologic unit codes, etc); resource setting data (soil, climate, plant/crop, etc); research/observed data; model parameter data; and land management operations data (tillage, fertilization, harvest, etc.).

Invasiveness – The extent to which a modeling framework imposes API dependencies on models and their components.

Knowledge Base – In the OMS context, knowledge stored in machine readable form and represented by concepts, concept roles/properties, and role/property constraints. In OMS, knowledge bases will be used to (1) manage model and component metadata, including relationships; (2) manage core agro-environmental concepts, and (3) develop non-computational reason-based model components.

Model – An assembly of components that perform a set of tasks that simulate biological, physical, and economic responses to management inputs to an agro-environmental system; in some contexts a model can be considered a compound component.

Model Base – A repository of related models and their instances, organized to address one or more related business needs. Model validation, certification, and data provisioning resources are consolidated and coordinated around a model base.

Model Service – A model packaged as a service, usually a web service, registered, and deployed on a service oriented architecture (SOA) compliant platform.

Multithreading – In the OMS context, running several instances of models or components simultaneously on several processors; intended to satisfy computing demand for sensitivity and uncertainty analysis, and for business applications running model services under heavy user load.

Ontology - a formal representation of a set of concepts within a domain and the relationships between those concepts; used to reason about the properties of that domain, and may be used to define the domain.

Service Oriented Architecture (SOA) – From SearchSOA.com "a service-oriented architecture (SOA) is the underlying structure supporting communications between services. SOA defines how two computing entities, such as programs, interact in such a way as to enable one entity to perform a unit of work on behalf of another entity. Service interactions are defined using a description language. Each interaction is self-contained and loosely coupled, so that each interaction is independent of any other interaction."

UDDI Registry – Universal Description, Discovery, and Integration (UDDI) web services registry designed to be interrogated by SOAP (simple object access protocol) messages and to provide access to Web Services Description Language (WSDL) documents describing the protocol bindings and message formats required to interact with the listed web services.

USDA Program – Legislation is translated into programs run by a USDA agency; a conservation or agro-environmental program delivers technical and/or financial assistance to recipients, usually agricultural producers.

OMS Goals and Objectives

The strategic direction and vision for OMS is towards solidifying its position as the modeling framework to support USDA agency program delivery and accountability, increasing its use and acceptance throughout the Department. Four goals support the vision.

Goal 1 –The USDA agro-environmental modeling portfolio expands to meet priority business needs; USDA supported scientists build models and components consistently, efficiently, and interchangeably using the OMS framework to deliver the best science to aid decision makers in managing and conserving the nation's land resources.

Objective 1 – Develop core model bases each for (1) farm/field level decision support, (2) farm/field level practice design, (3) seasonal natural resource forecasting, (4) basin/watershed assessment, and (5) ecosystem services determination.

Modelers establish core model bases extracting the best science from legacy models and new science components to build a model satisfying the business need. As appropriate, they then modify the model to create instances for the various regions within the projected area of use. The model instances comprise the model base. The model base is deployed as a series of model services that accommodate the requirements of the business applications using the model. User organizations structure data provisioning and model calibration support around the model base.

This approach breaks the obsolete pattern of building many (hundreds of) individual stovepipe models, and increases the probability for adequate data provisioning and calibration support.

Four of the model bases and their interaction with the generalized USDA conservation program delivery workflow are shown in Figure 2.

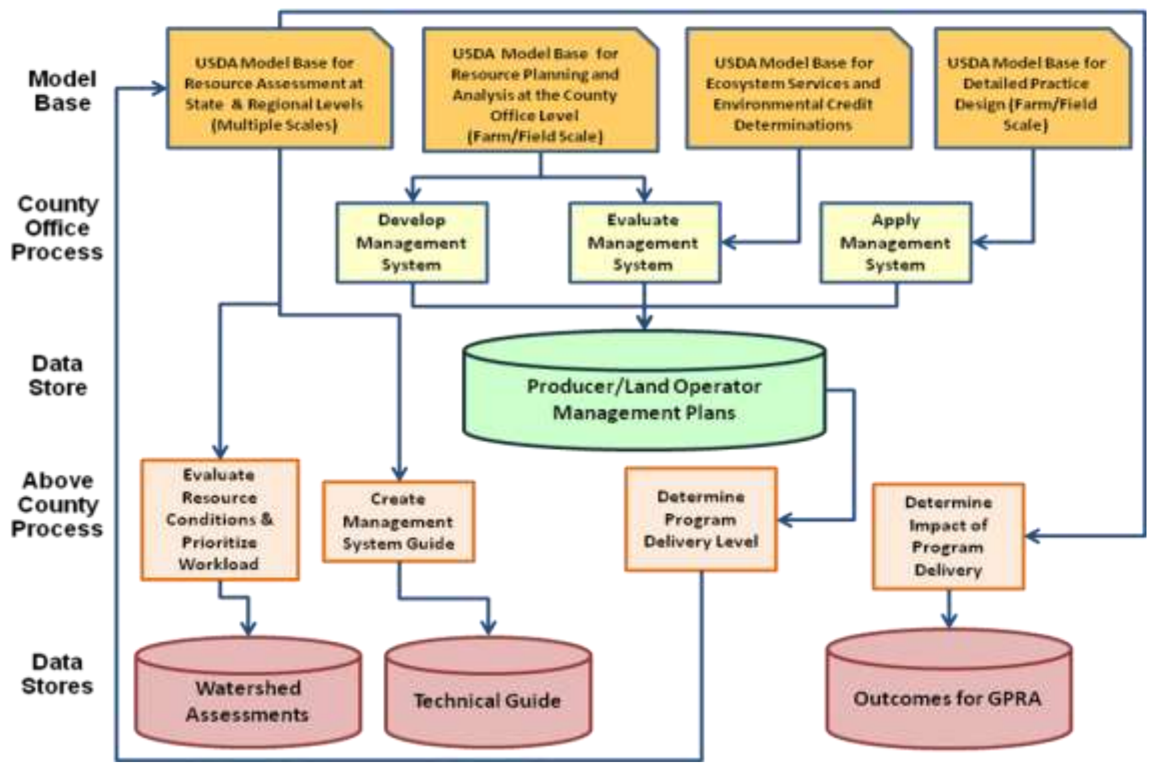

Figure 2. Four USDA model bases support prioritizing workload, giving technical assistance, providing decision support to agricultural producers, applying practices, trading environmental credits, and determining program outcomes.

<u>Farm/Field Level Decision Support Model Base</u>

USDA and partners provide daily technical assistance to agricultural producers at the farm/field level. The current available suite of stand-alone resource analysis tools will be replaced by this model base that analyzes erosion, nutrient fate and transport, pesticide fate and transport, forage production and utilization, and other priority resource concerns. These analyses enable the producer to decide the best management system for their operation. The decisions are recorded in the producer's conservation plan.

The same model base also can be used for management system planning on public land. In fact, a producer's conservation plan can contain both private and public land units, developed through a coordinated resource management planning process.

Expected sources for the science components in this model base include the Revised Universal Soil Loss Equation (RUSLE2), Agricultural Policy/Environmental Extender (APEX), Combined Wind and Water Erosion Model (WWEM), Grazing Spatial Analysis Tool (GSAT), Manure Management Planner (MMP), Phosphorus Index (PI), iFarm, and others. RUSLE2 will be deployed as an OMS model service in 2009 to support use of the existing version of MMP in the field.

Farm/Field Level Practice Design Model Base
USDA and partners assist the design of practices in the producer's management system plan. The practice design model base will provide science computation services for business applications that produce the requisite specifications and drawings.

Expected sources for the science components in this model base include the NRCS Engineering Field Tools (EFT), Agricultural Waste Management (AWM), Manure Management Planner (MMP), Vegetative Planting Specifications (VegSpec), and others. Initial practice design calculation services will be deployed in 2009 to support EFT. A surface runoff calculation service based on the NRCS Runoff Curve Number (RCN) has been prototyped on the OMS run-time platform, and with three other services in development, represents the first instance of the model base.

Seasonal Natural Resource Forecasting Model Base
USDA provides forecasts of water supplies to rural communities, water management districts, and agricultural producers. USDA research has developed methods to forecast forage and crop production within season. The Precipitation and Runoff Modeling System (PRMS) represents the first instance of this model base, supporting the move to model-based water supply forecasting in 600 basins in the western U.S. from the current regression-based method. PRMS is being deployed through OMS in 2009.

Basin/Watershed Assessment Model Base
USDA agency program managers and oversight staff analyze program effectiveness and accountability at multiple scales. USDA agencies also develop watershed level assessments in order to identify priorities and allocate program funds. The basin/watershed assessment model base will support both activities.

This model base currently contains components developed to assemble the next generation USDA Conservation Effects Assessment Project (CEAP) model. Science component sources include hydrology from the J2000 model, nutrient and pesticide fate and transport from the Soil and Water Assessment Tool (SWAT), RUSLE2, and other models. The model base will be used to assess USDA conservation program effectiveness across the country, with model instances tailored to regional conditions. The first operational version will be completed in 2009 for the Cedar Creek test watershed in Iowa.

Ecosystem Services Determination Model Base
Agricultural producers provide ecosystem services on their land. The role of USDA in environmental credit trading is emerging. It is likely that USDA agro-environmental models will

be leveraged for this activity. The ecosystem services determination model base will support USDA involvement in this area. Expected sources for this model base are the NRCS Nitrogen Trading Tool (NTT) prototype and the CENTURY model developed by the interagency Natural Resources Ecology Laboratory.

Additional model bases may be defined for other USDA business cases. For example, a separate model base could be established for certain public land management programs administered by the US Forest Service. Separate research model bases probably will be established to support specific areas of USDA research. However, the substantial resources required to provision data and calibrate models across regions will preclude a proliferation of model bases within USDA.

Objective 2 – Build a robust data provisioning service for model bases in OMS.

A model requires adequate data provisioning to in order to deploy it across the intended area of use. To function, the model needs data from these categories: (1) management applied to the land, (2) resource setting, (3) common reference, (4) observed/research, and (5) parameter values. Management inputs can be data entered by the model user, or pre-packaged data selected by the user. Resource setting data includes soil, climate, plant, and other location dependent, mostly static data. Common reference data includes crop names, plant names, pesticide names, land use, etc. Observed/research data contain the model output elements, enabling model calibration and validation. And model parameter values correspond to internal model data elements and are adjusted during the calibration process, and persisted for future model runs.

USDA manages substantial agro-environmental data assets, however, not in a sufficiently coordinated way to support expanded model development and use. The following steps will be taken to establish data provisioning for models using the OMS framework.

1. Create data marts containing resource setting data including soil, climate, plant, and other natural resource elements required by OMS model bases. Develop and deploy associated SOA compliant data access services.

2. Leverage access to existing USDA spatial data resources, including orthoimagery, digital elevation, etc. Sources include the NRCS National Cartographic and Geospatial Center and the three Remote Sensing Laboratories. Also geospatial data centers operated by the US Forest Service, Foreign Agricultural Service, and Farm Services Agency.

3. Establish an agro-environmental reference data standard, leveraging the existing USDA service center agency master reference data definitions, and coordinating with other modeling framework data dictionaries and ontology.

4. Create a land management operations data mart (a database of pre-packaged management alternatives).

5. Expand the ARS STEWARDS research database system and integrate with data collection and stewardship capabilities within USDA agencies to create OMS model base parameter and validation datasets for appropriate regions across the U.S.

6. Leverage access to NASA Earth Science data and to other sources via facilities such as EPA's Data for Environmental Modeling (D4EM).

<u>Objective 3</u> – Create knowledge bases to facilitate understanding the relationships among OMS models and their components, and to facilitate the interaction of computational and non-computational knowledge.

<u>OMS Model and Component Knowledge Base</u>
As the OMS model and component library increases in size, high quality meta-data enables modelers to sort through and understand the content in the repository. An OMS model base rests on the concepts and their relationships derived from business requirements and the science applied to satisfy these requirements. Organizing this knowledge is best done using semantic technologies. Therefore an OMS knowledge base will be established using web ontology language (OWL).

<u>USDA Agro-Environmental Knowledge Base</u>
Integrated modeling must rely on a common understanding of basic concepts and their relationships. Science components can be aggregated into compound components and further assembled into larger compound components. At some point, the compound component is declared a model supporting a defined business need. Models deployed as services must share a common understanding of core concepts with the business applications that use them. Core concepts include landscape unit, management unit, response unit, management system, conservation practice, land use, among others. Therefore an agro-environmental knowledge base facilitates efficient modeling, especially for complex projects.

Most science components represent computational knowledge. They persist as executable computer code. Inputs (another form of knowledge) for computations reside in relational databases or other data structures. Conceptual knowledge is a third form.

In USDA conceptual knowledge mostly is persisted as text in hard copy documents or static HTML pages. For example, USDA ecological site state and transition models (STMs) currently are diagrams in HTML on a web site. STMs become much more useful if they are converted to become part of a knowledge base that can be exploited by business applications. Semantic technologies are part of the Web 2.0 initiative, and OMS model bases are expected to interact with knowledge bases in the future.

<u>Objective 4</u> – Develop and support a cadre of OMS modelers

Concentrating on the five core model bases discussed above will help to organize resources around the respective teams of modelers formed to build and maintain them. The OMS modeler will be a scientist proficient in Java, or a scientist with one or more assigned programmers proficient in Java. Removing OMS framework dependencies from model code will shorten the learning curve for new modelers.

The OMS strategy includes obtaining USDA agency support to a core cadre of OMS modelers. Research agencies contribute scientists and programmers to develop science components and models. Action agencies may support modelers and programmers to create model instances to extend a model base across the intended region of use. USDA also will leverage product developed by OMS modelers from external agencies and organizations.

Annual OMS training will help modelers to keep current with the framework and new technologies as they are incorporated. The strategy includes coordinating with partner universities to work OMS into curriculums containing classes on modeling techniques.

OMS does not exclude modelers from contributing components in other languages to the OMS Component Library.

Goal 2 – Agro-environmental model use increases to become ubiquitous at the field and watershed scales in the country.

Most computing platforms in use today constrain model use outside the research community. As a result user communities tend to be small and normally number in the tens or hundreds, and rarely in the thousands. As a model becomes more popular, resources must be diverted to support users and the platforms on which the models run. Modeling communities have not taken advantage of recent advancements in computing technologies, at least not to the extent that the commercial world has done with their very large user communities. Scientific model use also is severely constrained by deficiencies in data provisioning.

<u>Objective 1</u> – Deploy OMS models as registered advertised services to run on an elastic computing cloud platform.

Organizations increasingly are moving their business applications to run in commercial server farms, termed “cloud computing” (Armbrust et al 2009). They purchase capacity on an as-needed basis, adjusting periodically to fluctuations in user load. Doing so significantly reduces production costs and avoids the distraction of diverting and committing resources to maintain an internal platform.

USDA agency business applications will incorporate science deployed as OMS services. For example, an agency conservation planning application may involve running an erosion estimation model. Initially, the expected load may be 100 concurrent user sessions, and in the longer term 1,000 sessions. The erosion model has been deployed as a service to the computing cloud with capacity configured to accommodate 100 concurrent sessions. Use is monitored, and through time the capacity is incrementally increased to accommodate 1,000 sessions. The agency is charged for capacity used, but the service is much more responsive and less expensive than owning and managing it in-house.

OMS services deployed to the cloud must be coordinated, and this will depend on the number of business applications and their demand on particular services.

<u>Objective 2</u> – Enable multi-threaded model runs on the production platform.

Agro-environmental models often are process intensive, where components may be exercised thousands of times during a model run. Therefore to increase performance, the work performed by a model must be allocated (threaded) to the processors available in the production platform. For example, a design may require accommodating at least a thousand users running a model containing several components, through thousands of time steps per run.

The OMS strategy involves leveraging multi-threading technologies recently employed by on-line gaming industry that often engages millions of simultaneous users.

Objective 3 – Calibrate and validate OMS models by physiographic regions in a coordinated and consistent manner.

Increasing model use through availability as a service depends on calibration and validation for the regions in which the agency program is delivered or business interest served. The OMS strategy envisions a coordinated and integrated support structure to ensure the calibration and validation are done and kept current.

The strategy involves integrating the following capabilities across agencies and organizations:

1. Adapt the STEWARDS database to create an open source version. Consolidate, add, and maintain research data sets in STEWARDS across USDA agencies. Consolidation involves access to and compilation of research datasets from USDA, other departments and agencies, and university sources.

2. Design and add model parameter data tables to STEWARDS.

3. Where necessary, establish long-term projects to collect data and fill in gaps.

4. Establish a model validation network involving participating ARS research units, the three NRCS technical service centers, National Water and Climate Center, and 26 plant materials centers. As appropriate, involve technical units in Forest Service regional offices. Model validation becomes an on-going coordinated effort driven by program needs and priorities. Model services deployed to a computing cloud must be pre-calibrated for the areas of intended use.

Objective 4 – Develop and deploy data access services in the OMS computing cloud.

Each model service deployed to a computing cloud must have access to the data required to run it for the areas of intended use. For example, an erosion estimation service deployed to the cloud for the western Great Plains must be able to run against applicable soil, crop/plant, and climate data for the region.

As discussed above under Goal 1, several agencies and organizations manage regional and national databases and warehouses containing data needed for OMS model runs. In addition to provisioning data for model development purposes, the OMS strategy includes a process to provision data to the production platform. In the case of model services in the cloud, the data may be deployed in three ways:

1. File storage service (e.g. Amazon S3 Storage)

2. Simple database service for fast retrieval of subsets of very large datasets (e.g. web service on top of Netezza, a parallel processing data warehousing appliance)

3. Traditional relational database service (e.g. Amazon Elastic Block Storage)

Some providers honor existing licensing to cover instances of their DBMS in the cloud.

Goal 3 – USDA scientists develop models in OMS and apply them to synthesize research results across locations and extend them to multiple weather and soil conditions on a regional scale.

Objective 1 – Establish policies to promote the use of OMS to integrate systems modeling with field research.

USDA scientists often use modeling as a tool to analyze and interpret research results. However, lack of a modeling framework inhibits greater integration of modeling with research projects. OMS enables consistent and efficient modeling for research purposes, taking advantage of tools for calibration, sensitivity analysis, and uncertainty analysis. Researchers using OMS leverage a shared science component library and data provisioning services. OMS provides a common platform for collaborative research projects across regions. Therefore it can substantially increase the integration of modeling with field research.

The OMS strategy calls for USDA research leadership to promulgate policies to encourage the use of the framework to integrate systems modeling in research projects investigating agro-environmental problems and issues. Leadership and guidance from the ARS National Program Staff is crucial. Involvement and direction from USFS research leaders also is important. The OMS team expects to be engaged with staff work to develop and promote the applicable policies.

Objective 2 – Develop consistent state-of-the-science research models for priority problem areas.

USDA research projects generate new agro-environmental technologies. They deliver them packaged as written material, physical product, and/or computer code. OMS packages computer code technology as components, or compound components called models. The framework enables a research model to be built efficiently and collaboratively by scientists in different locations.

The ARS Agricultural Systems Research Unit (ASRU) at Fort Collins, Colorado will develop and demonstrate model bases in OMS for the following research problems, involving partner scientists from multiple locations:

- Management strategies optimizing the use of limited water and soil resources.
- Agricultural systems to conserve non-renewable resources, improve environmental quality, and sustain production for different soil and climate conditions.
- Adaptive strategies to mitigate projected effects of climate change on agriculture and the resource base; projected effects of agriculture on soil carbon and greenhouse gas emissions.
- Long-term potential and sustainability of bio-energy crops.

As OMS moves forward, new research model bases will be organized around priority initiatives. Research model bases focus on research problems and are not directly used by program delivery agencies. Many science components and models in a research model base will mature to the point where they are candidates for technology transfer. They will be transferred to one or more of the model bases designed around program delivery agency needs, deployed as services and integrated with appropriate agency business applications.

Objective 3 – Facilitate collaborative modeling and delivery of science models and components to USDA program delivery agencies.

ASRU developed the OMS framework and continues a lead coordination role to incorporate scientific components into model bases that serve the business interests of USDA agencies. With NRCS and other agencies, ASRU will coordinate the development of core concepts in the agro-environmental domain and management in a knowledge base to support both research and program delivery modeling with OMS. The research unit will design, build, and coordinate the stewardship of the research data warehouse supporting OMS model bases. ASRU will coordinate the resolution of problems and issues with other research units engaged in agro-environmental modeling with OMS.

Goal 4 – Agro-environmental models and components are deployed and used across frameworks facilitating collaborations between USDA and external partners.

A primary OMS strategy is to formalize the common modeling framework for all USDA agencies. Although most Department programs focus on national problems and opportunities, their context often is international or requires understanding of issues and trends across countries and continents. Therefore OMS models and components should be applicable internationally, and accessible to other modeling frameworks, including those used within the country by non-USDA agencies for their program purposes. Interoperability with other frameworks also would promote science model and component exchange.

Objective 1 – Create and apply a non-invasive model development standard.

Most environmental modeling frameworks impose constraints on modelers by tightly bounding model code to the framework and limiting its usefulness externally. The framework therefore is considered invasive. The modeler makes a big commitment to the framework. However, the modeler working from scratch without a framework usually is in worse shape. The solution is to eliminate framework invasiveness.

The OMS strategy includes creating and documenting a standard guiding the development of OMS science components as “Plain Old Java Objects” (POJOs). They are bound to the framework through configuration files or framework specific annotations. Modelers therefore do not incorporate OMS API dependencies in their model code. Next generation OMS 3.0 becomes an annotation-based framework. Subsequent OMS versions will support previous version annotations, and the model code in the repository will not be aware of changes to the underlying framework.

The advantages of non-invasive OMS 3.0 are expected to be:

1. Models and components developed with OMS 3.0 can be easily decoupled and migrated to another framework.

2. OMS can be more easily upgraded with little to no change in model code as long as previous configuration methods (e.g. annotations, XML) are supported.

3. Model components are more easily unit tested because they do not contain framework dependencies.

4. Modelers will have shorter learning curves not having to wade through complex framework classes, interfaces, and APIs.

5. POJOs implement methods with pre-determined names, avoiding long and complex configuration files.

6. Model code integrates with supporting technologies more transparently, making it less error prone.

<u>Objective 2</u> – Establish OMS as an open source community modeling system with appropriate governance.

OMS is an open source modeling framework. Initially, OMS solidifies as the recognized modeling framework for USDA, and in the longer term positioned to become a community framework along the lines of LINUX as open source operating system or GRASS as open source GIS. A community OMS would require the formation of an organization to apply appropriate governance and facilitate interaction among and contributions from community members.

<u>Objective 3</u> – Develop collaborations and relate OMS with other major modeling groups and frameworks.

The OMS strategy includes collaboration with other modeling communities and their frameworks. The OMS team expects to synergistically interact with the:

1. Open Modeling Interface (OpenMI) Association – Funded by the European Commission, this group manages a framework that links agro-environmental models together to assist policy and program decision making. Model developers make their existing or new models OpenMI compliant, which enables them to be run in concert with other models. The effort to this point has been at the model level, and in this context a modeler working with OMS could build components and create a model, and then make it OpenMI compliant. OpenMI supports .Net and Java, and the OMS strategy anticipates significant interaction with the Java side of the OpenMI association.

2. Community Surface Dynamics Modeling System (CSDMS) – Funded by the National Science Foundation, the University of Colorado-Boulder is (1) developing a modular modeling system to advance fundamental earth system science, and (2) developing repositories for data, models and numerical tools, and educational use. They are leveraging the Department of Energy’s Common Component Architecture (CCA) used by

the National Laboratory system, and interacting with other efforts, including OpenMI and OMS, to lay out their system. The OMS strategy anticipates cross-over benefits between fundamental earth science research and science applied to agricultural lands.

3. Framework for Risk Analysis of Multi-Media Environmental Systems (FRAMES) – The Environmental Protection Agency (EPA) currently uses this framework to link existing and new models together to assist policy and program decision making. They also are working on a data provisioning service called Data for Environmental Modeling (D4EM). They currently interact with the OpenMI Association, and their modeling unit at Athens, Georgia and the OMS team interact through the Interagency Steering Committee for Multi-Media Environmental Modeling (ISCMEM) and work together on several issues. EPA is interested in certain OMS features and the direction towards cloud computing. The OMS strategy expects increased joint work on framework components useful to both parties, in particular data provisioning.

4. US Geological Survey (USGS) – The Modular Modeling System of the 1990s is a precursor to OMS, and the USGS National Research Program Central Region hydrologic modeling unit in Denver and OMS team continue to work together to add or improve features, which are incorporated into OMS.

5. Jena Adaptable Modeling System (JAMS) – This is the European instance of OMS, managed by the Friedrich Schiller University of Jena in Germany. The OMS and JAMS teams interact several times per month and will continue to work on features to enhance both systems.

The OMS team expects to remain active in organizations such as the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), the International Environmental Modeling Software Society (IEMSS), and ISCMEM.

OMS Business Use Cases

As part of the USDA technical architecture, the OMS framework will support several business use cases across the agencies in the Department.

Develop management alternatives with the producer or land manager. A local USDA service center agent responds to a request for technical assistance from the producer. The agent provides advice and may interact with the producer to develop a solution to one or more problems. Doing so may involve running a model to estimate the effectiveness of a solution. For example, the producer may want to optimize fertilizer applications to minimize leaching and run-off losses, repair a gully, or adjust stocking rates in a grazing system. This type of activity occurs daily across 3,000 USDA offices, and is supplemented by the efforts of third party technical service providers. The applicable models (and data) must be available on demand, perform well with several concurrent user sessions, and calibrated and certified as best available science, regionalized as appropriate.

Develop detailed practice designs. A local USDA service center agent develops a detailed design of a practice to be installed by the producer, for example terraces. The height and spacing of the terraces depends on the analysis of the hydrology of the area to be treated. The design process may involve running a model service. As with the previous use case, this type of activity occurs daily across all county level USDA offices and also involves third party technical service providers. The models and data must be certified best science and highly available.

Determine USDA program eligibility. A local USDA service center agent runs a model to determine whether a producer is eligible to participate in a program, often during a brief sign-up period. Therefore the model (and data) must be available during this period and deployed to perform well under heavy user load. Program legality also requires the model to be certified for the specific purpose and consistently deployed to preclude fraud. The program eligibility process also may allow producer self-service, which would require the model service to be available on-line 24x7.

Determine USDA program compliance. A local USDA service center agent runs a model to confirm a participating producer has complied with program requirements. The process also may permit the producer to self-certify compliance. Compliance checks may occur within a small time window. As with the previous use case, the model service must be certified and highly available.

Assist tactical management decision making. A producer or the producer's consultant runs an application against model services that help analyze options for management actions within the growing season. For example, the producer faces a water shortage and must adjust irrigation and take other management actions to increase the probability of a successful crop. This use case also applies to the public land manager who adjusts management to respond to changes to within season conditions. Model services must be highly available and documented as best science.

Assess program effects and outcomes for oversight and evaluation reporting. A USDA agency analyst runs a model to analyze the effectiveness of a program across the areas where it is delivered. The analyst probably is located in a state, region, or national office and a member of a team of analysts. The models must be calibrated and certified for the regions to be evaluated, and perform well under moderate user load.

Develop watershed assessments to support program resource allocation. USDA agency team members run models to analyze resource conditions to identify areas needing program emphasis and the potential solutions and resources for service delivery. The assessments are conducted as part of a typical strategic plan cycle of 5-8 years. The models must be calibrated and certified best science for the regions to be evaluated.

Calculate credit for ecosystem services. Environmental or conservation credit trading will expand and diversify in the future, particularly as cap and trade systems are established. Models will be used to determine offset rates. Model runs probably will be a background (and not real-time) process for this business requirement in the foreseeable future. Conceivably, model runs would be documented and perhaps digitally signed and associated with the applicable rate structure.

Model services also will support determining the extent and level of ecosystem services provided by a particular farming or land management operation. Related are analyses that determine the extent to which a management system is carbon neutral. Ecosystem services and carbon neutrality are important to the Conservation Security Program (CSP) and other expected future programs that provide compensation for these services.

Support risk management programs. Crop insurance programs are administered based on yield data collected by the USDA National Agricultural Statistics Service (NASS). Crops models are being considered to establish yields in counties where statistics for a crop are not gathered.

Summary of Requirements for a USDA Modeling Framework

USDA contains several agencies that need agro-environmental model support for program delivery, including ARS, NRCS, Forest Service (USFS), Farm Services Agency (FSA), Risk Management Agency (RMA), Economic Research Service (ERS), Animal and Plant Health Inspection Service (APHIS). A USDA modeling framework should satisfy the following requirements.

- A component-based architecture so models and components can be rapidly modified and adjusted to emerging and changing business needs.
- Organization of components into model bases around consolidated business cases, in order to efficiently structure and allocate resources to support them.
- Organization of components into model bases so that model instances can be tailored to regional needs.
- Models are deployed as services to a production platform and integrated with business applications and portals. Services comply with a service oriented architecture (SOA) standard. Several applications or portals may run against a model service, or conversely, several instances of a model service may be deployed to meet different business needs.
- Models are deployed to scale and perform well under heavy user load. This may involve hundreds to thousands of users concurrently operating business applications that run against model services, or one user spooling hundreds of model runs for intensive sensitivity or uncertainty analyses.
- The framework is non-invasive, meaning model component code should not contain framework API dependencies. The model developer should be able to build a component or model irrespective of framework, and use it across frameworks.
- A robust data provisioning service enables models to be calibrated, validated, and to support business applications across their intended area of use.
- A knowledge base provides for explicit definition of model components and their relationships to and dependencies on other components and entities.
- The framework contains features enabling a model to contain components compiled in languages other than Java.
- The framework contains a comprehensive suite of tools for sensitivity and uncertainty analyses, and is associated with a process for model validation across large regions of use.

OMS Architecture

The fully envisioned (To-Be) OMS framework will provide (1) a model development and validation platform for agro-environmental modelers, (2) a run-time platform for model services advertised to business applications, (3) a data provisioning platform to manage and supply data for models, and (4) a knowledge base platform to facilitate the integration of model output in business information systems.

The current (As-Is) OMS 2.2 framework primarily contains the model development and validation platform. Model users also can use the framework to run models to perform analyses relating to their business needs. The features and tools contained in OMS 2.2 are described in the tutorial found at http://oms.javaforge.com. The OMS application help and documentation menu provides the modeler access to additional documentation.

The workflow processes to develop, deploy, and support models with a fully realized OMS framework are shown in Figure 3.

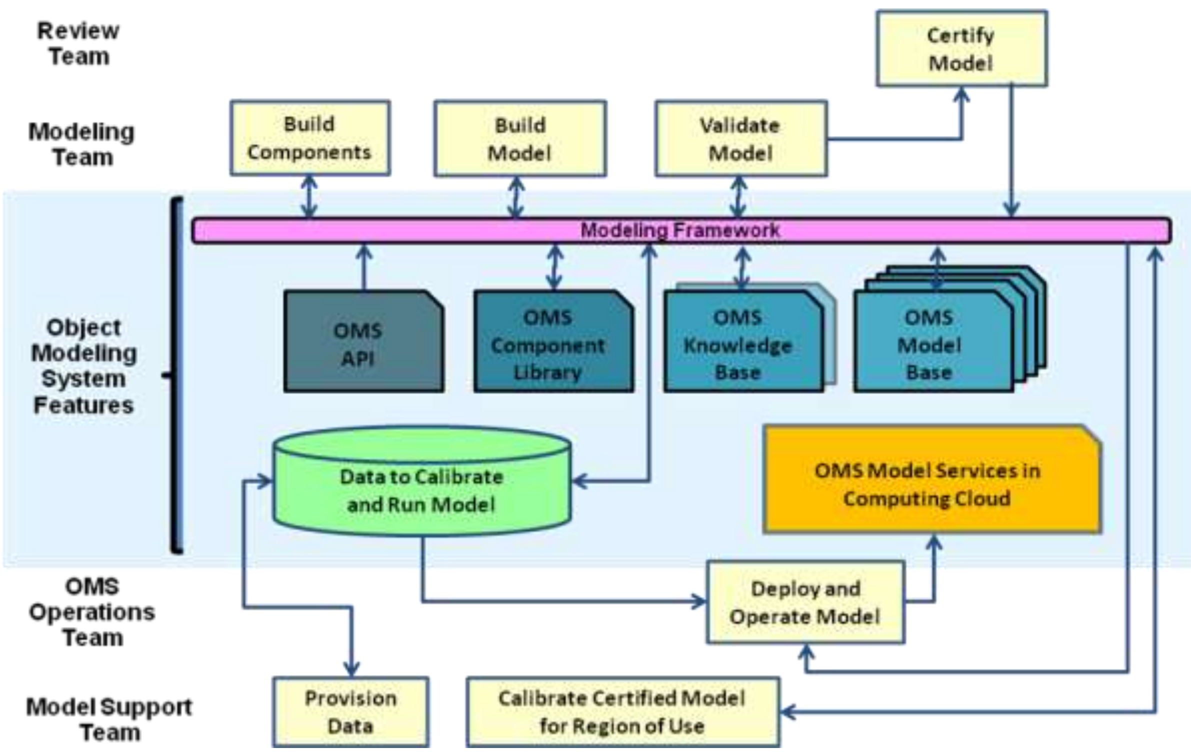

Figure 3. Generalized OMS model development, deployment, and support workflow.

The fully developed OMS architecture will be based on the following principles:

- Open source and platform independent integrated development environment (IDE) – the framework itself can be modified and updated by OMS community members.
- Component based modeling – components are software units that are context-independent both in the conceptual and technical domain.

- Non-invasiveness – to the extent possible, component code does not contain dependencies on the modeling framework.
- Virtualization – the framework takes advantage of computing infrastructure as a service.
- Knowledge management – model output, relational data, and conceptual information are integrated and purposed through semantic web technologies.

Model/Component Development Platform

Existing Features (OMS 2.2)

OMS 2.2 contains a model and model component development platform, enabling the modeler to create and maintain modeling projects. The OMS framework contains scientific utility, control and data input/output components. It contains a repository for scientific components developed by the modeler. Figure 1 displays the platform using the PRMS model as an example.

Modelers use the Component Creation Wizard to develop Java scientific components. They also can use the Native Component Creation Wizard to adapt legacy code in other languages to develop Java-wrapped scientific components. They use the Component Attribute Editor to manage component attributes and metadata.

OMS contains features to develop and execute models. Modelers use the Model Creation Wizard to build models containing components from the OMS repository. The Model Editor enables the user to (1) add components to a model, (2) remove components, (3) change component attribute connections, and (4) view declared attributes. OMS provides tools to debug the model.

Currently, the modeler uses the Model Creation Wizard to parameterize and execute the model, and visualize output.

OMS 2.2 leverages the Netbeans 5.5.1 IDE.

The OMS Component Library currently contains about 200 components (Appendix II).

New and Planned Features (OMS 3.0)

The USGS Luca auto-calibration tool (Hay and Umemoto 2006) has been added to OMS 2.2 providing a multi-objective step-wise procedure to develop parameter datasets across regions. The Shuffled Complex Evolution (SCE) global search algorithm provides the foundation for this tool.

During 2009, another auto-calibration tool will be added supporting the single objective dynamically dimensional search (DDS) method. Three sensitivity analysis tools will be added supporting the Morris screening, Extended Fourier Amplitude Sensitivity Test (FAST), and Sobol methods.

Other planned tools are the multi-objective Non-dominated Sorting Genetic Algorithm (NSGA) calibration method; and Generalized Likelihood Uncertainty Estimation (GLUE) and Bayesian Monte Carlo for uncertainty analysis.

The OMS Team recently has developed GeoWind (geowind.javaforge.com), which integrates open source GeoTools with NASA's World Wind GIS and an API for OMS models. It becomes the interactive front-end application for OMS users to delineate landscape units, calibrate the model, set up the model run, run the model, and display the output (Figure 4).

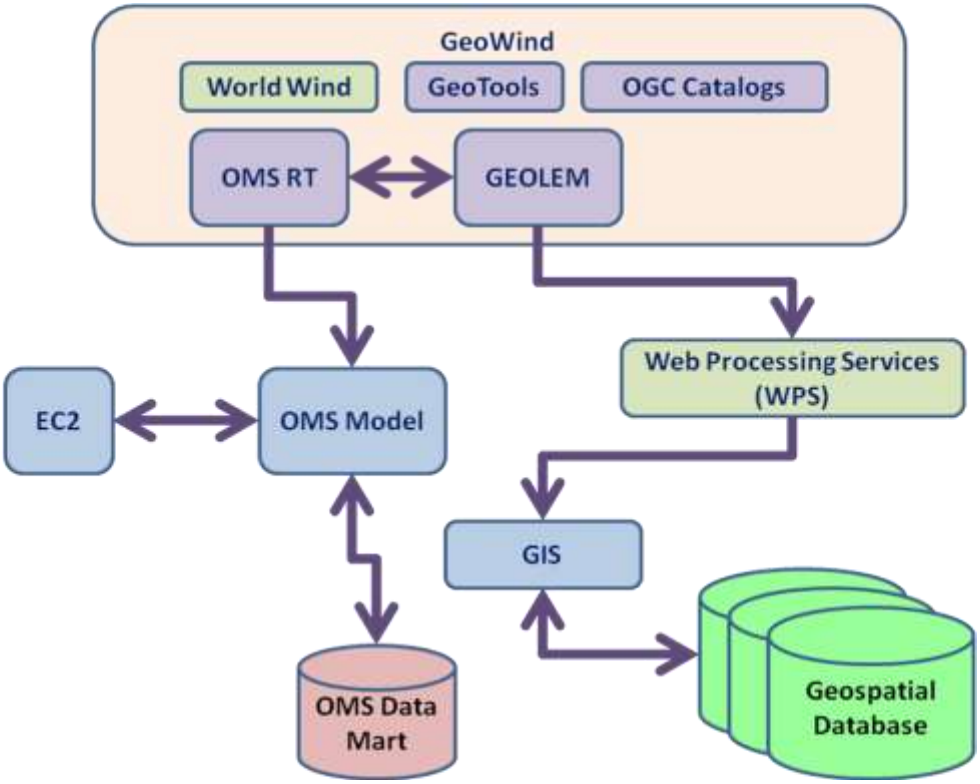

Figure 4. OMS geospatial user interface for model set-up and execution.

OMS also incorporates GEOLEM (Geospatial Library for Environmental Modeling), middleware that enables OMS model interaction with geospatial data for delineating and parameterizing geographic features, and analyzing model output visually (Viger et al 2007).

Next generation OMS 3.0 applies a new standard for developing model components, centered on the convention of components as Plain Old Java Objects (POJOs). See Figure 5. The new standard eliminates framework data types and interfaces. Execution is data driven. The modeler creates separate metadata for the component for execution control and connectivity, execution support, documentation and repository support, testing support, and run-time consistency support. The OMS component metadata annotation standard is presented in Appendix IV. The metadata can be inserted as annotations inside the component source code file, which can be easily extracted. At the modeler's discretion it also can be developed and managed as a separate Java annotation or XML file. Most of the existing components in active OMS modeling projects already have been converted to the POJO standard.

OMS 3.0 will support components written in other languages through Java Native Access (JNA). JNA enables calls into native functions using natural Java method invocation. For example, an OMS model could call a Revised Universal Soil Loss Equation (RUSLE) black box component compiled as a DLL.

OMS 3.0 also likely will support the use of two popular IDEs: the current Netbeans platform, and Eclipse.

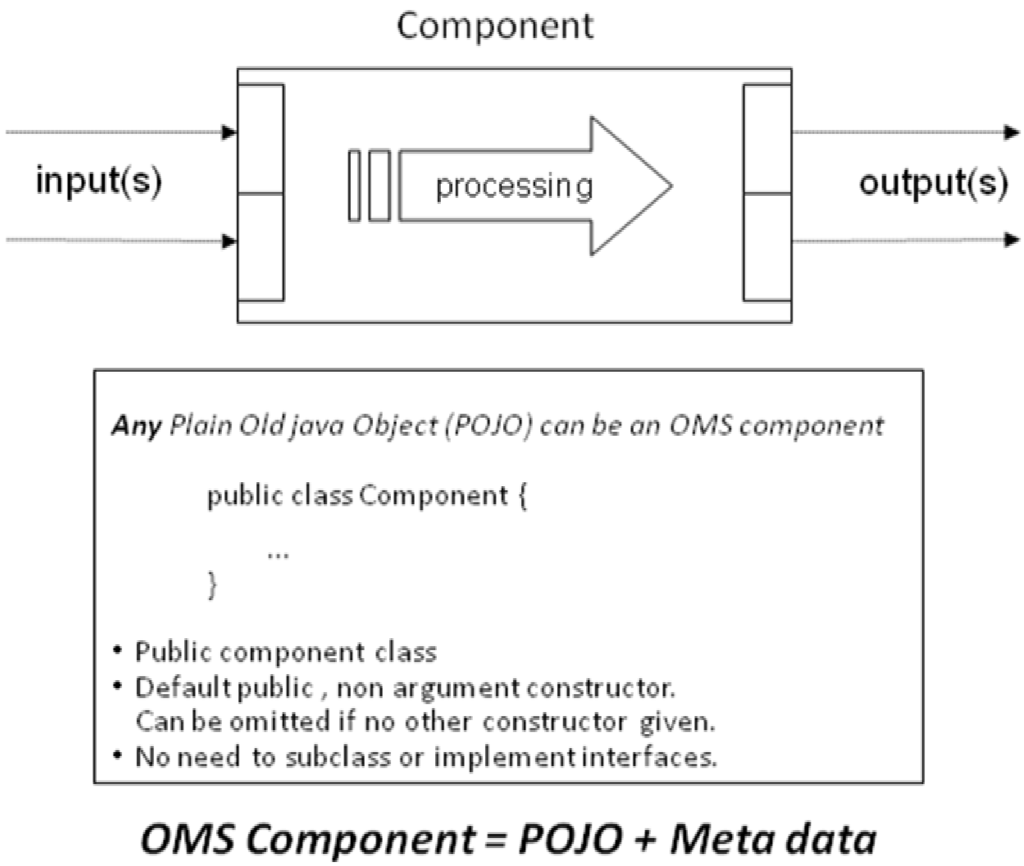

Figure 5. OMS 3.0 component standard.

Model Run-Time Platform

Existing Features (OMS2.2)

OMS 2.2 enables the modeler or a model user to run a model contained within the framework. The user must be trained in how to use OMS as an application to run the model. Running the model occurs independent of an automated business workflow.

New and Planned Features (OMS 3.0)

The OMS strategy assumes models will be integrated with organization business applications. Therefore the models must be packaged so that business application developers can add them to an automated scientific business workflow. Two approaches:

1. An OMS model is incorporated into a business application deployed to the organization's computing platform. The model is contained within the business application.
2. An OMS model is deployed as an advertised service to a computing cloud, available to one or more business applications.

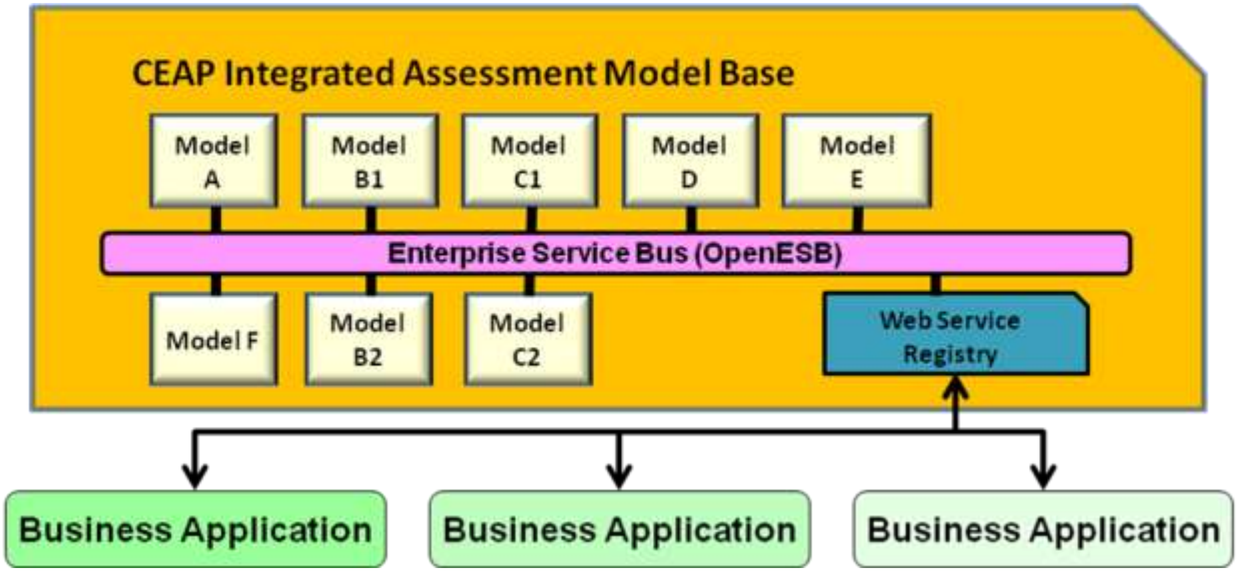

Figure 6. OMS model instances deployed as services to a computing cloud.

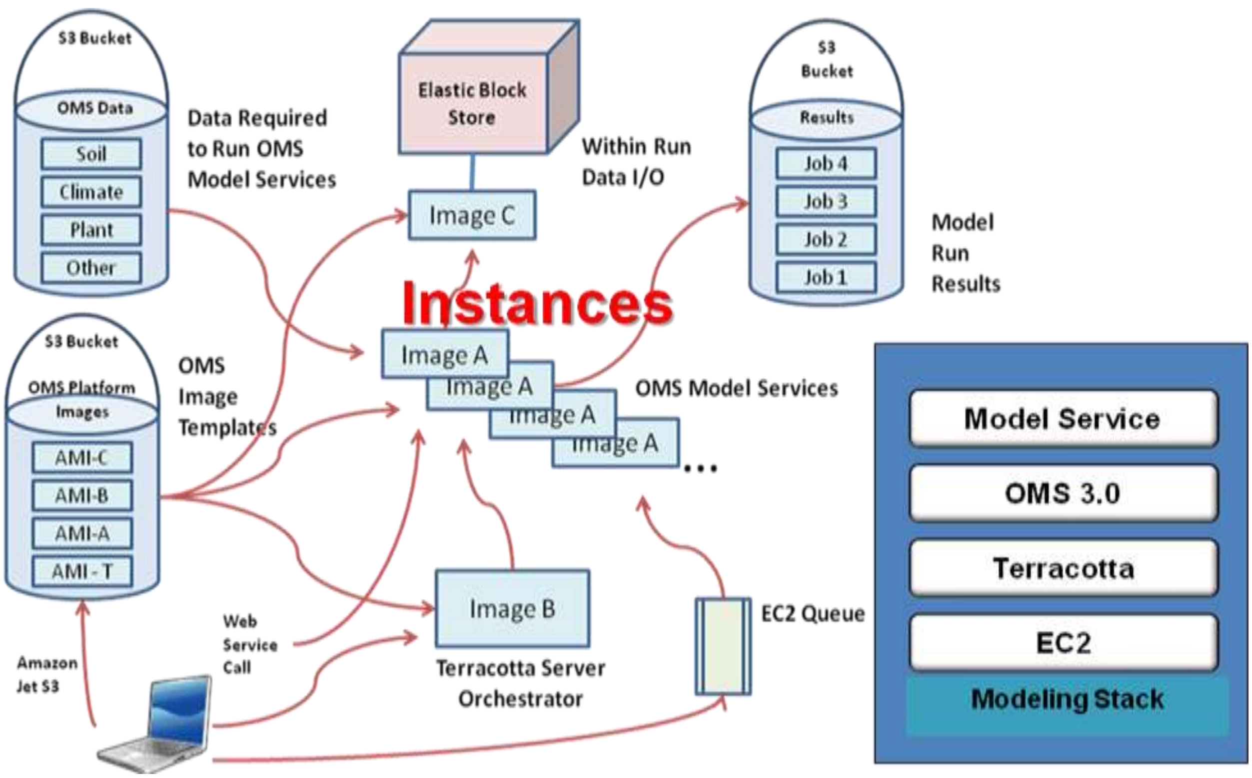

Figure 7. OMS multi-threaded model services deployed to a computing cloud (Amazon EC2 example).

The OMS strategy emphasizes the second approach. Figure 6 shows a generalized example of model services deployed to a computing cloud.

OMS model base instances will be packaged as SOA-compliant web services and advertised in a UDDI registry. The services will be deployed on an enterprise service bus (ESB). Presently, OMS uses the open source Glassfish Enterprise Server containing OpenESB and a UDDI registry (https://glassfish.dev.java.net/). Virtual servers are configured in an elastic computing cloud, Amazon's EC2 (http://aws.amazon.com), using Amazon machine images (AMIs), Simple Storage Service (S3), and Elastic Block Storage (EBS). Model service multi-threading is enabled through Terracotta's network attached memory (http://www.terracotta.org). System tools have been developed to manage the configuration and deployment of virtual server images and model services to the computing cloud.

Recently, the platform has been configured and tested with the Thornthwaite water balance model and the Runoff Calculator from the NRCS Engineering Field Handbook. Figure 7 shows a schematic example for configuring the computing cloud.

The OMS strategy expects relatively few USDA model bases, each containing several model instances, which are deployed as model services to the computing cloud according to business need and priority. Business applications run against the model services.

Some business cases will involve heavy user load during peak work periods, and therefore the applicable model services must be highly available. Model services will be multi-threaded to leverage computing capacity and accommodate load requirements.

Data Provisioning Platform

Agro-environmental models process data inputs to generate results. Several inputs establish the resource setting: soil, climate, crops, producer management, etc. The data is either entered by the model user, or the model consumes it from electronic data storage. The less data entered manually by the user, the better, particularly for heavy use models.

The generalized approach to provisioning data to OMS models is shown in Figure 8, whether for soil, climate, or other data required to establish the resource setting.

Data providers collect data and manage it in data storage architected to facilitate the data collection process. They apply quality control and often may process the data to produce data products ultimately consumed by the models. The products are transferred (extract, transform, and load; or ETL) to a data warehouse where it is certified as an authoritative source. Data stewards are assigned to ensure the integrity of the data.

The OMS strategy includes creating data marts for the respective model bases. Through an extract, transform, and load (ETL) process, soil, climate, crop/plant, and other resource setting data will be provisioned to an OMS data mart designed for the particular model base. Model base developers will create data access services enabling models to run against the data mart. The data access services will be SOA compliant and advertised to promote use beyond the model base.

The models also require research (observed) data so they can be calibrated. The calibrated model contains parameter datasets that must be storage and appropriately managed. Observed and parameter data will be organized by regions. Each OMS model base will contain a calibration data mart.

An OMS model base will contain model instances appropriate for specific regions of the country, and data provisioning will be organized around these regions. USDA integrated assessment of conservation effects (CEAP) has delineated regions aligned with Major Land Resource Regions (MLRRs). These regions (Figure 9) can form the basis for a USDA data provisioning support infrastructure.

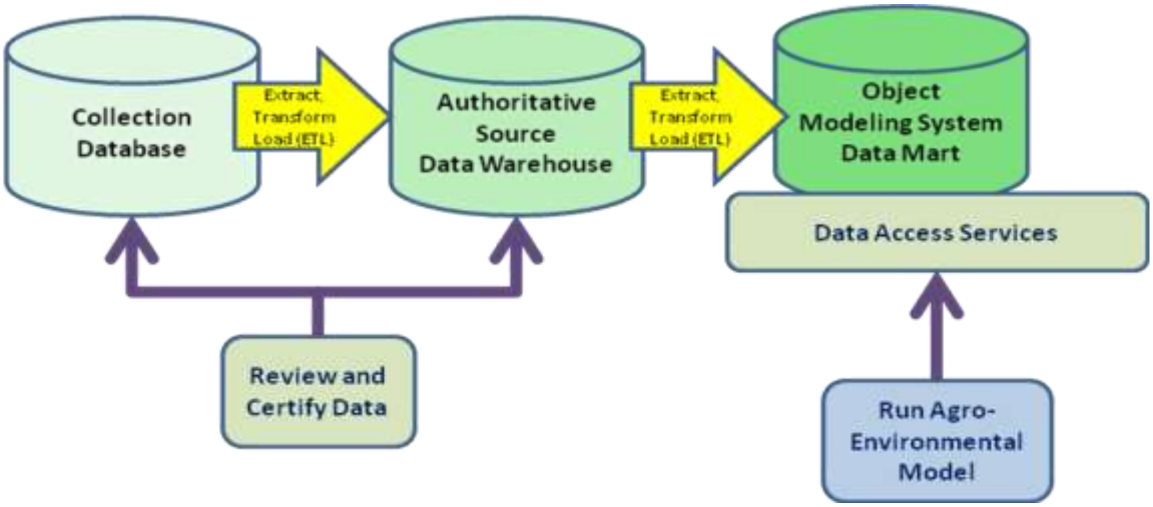

Figure 8. Generalized OMS data provisioning approach.

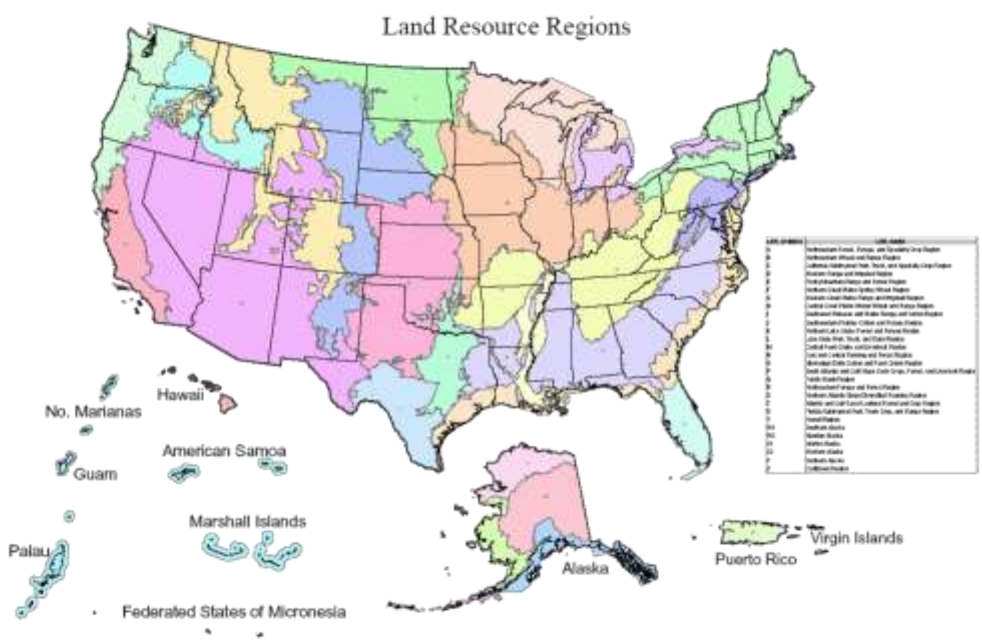

Figure 9. Major Land Resource Regions (MLRRs) as a foundation for data provisioning and calibration support to OMS model bases.

Data provisioning support will require a significant commitment to coordinate the resources necessary to facilitate widespread use of model services. Likely resources include:

- NRCS Technical Support Centers
- ARS Research Units contributing to the STEWARDS research data system
- USFS Region technical staffs
- USFS Forest and Range Experiment Stations
- NRCS National Water and Climate Center
- NRCS Cartographic and Geospatial Center
- NRCS National Soil Survey Center
- NRCS Remote Sensing Laboratories
- NRCS Plant Materials Centers
- NRCS State Office technical staffs

Data stewardship and model calibration teams should be established for each major MLRR, or perhaps combinations of regions, to support the OMS model bases. The 28 MLRRs probably can be consolidated to 10-15 data provisioning and calibration regions. Teams could contain (1) dedicated agency staff or multi-agency staff at a single location, or (2) dedicated staff across multiple locations. Teams could be virtual and ephemeral in nature, consisting of assignments to agency or multi-agency staff across locations.

Increasing model use within USDA represents a step forward in science-based decision making and analysis, and should replace outmoded legacy processes. Therefore, data provisioning and model calibration support should not be considered an add-on responsibility. Old processes are replaced with the new approach.

Data provisioning is a major constraint to improved science-based analysis and decision making through the use of models, and therefore it is crucial a detailed data provisioning infrastructure and implementation plan be developed and approved in the short term.

Knowledge Base Platform

OMS will establish two knowledge bases in OWL, leveraging to the extent practical already established ontology, such as those established by CUASHI (Consortium of Universities for the Advancement of Hydrologic Science, Inc.) for hydrologic modeling, and perhaps the European SEAMLESS project, which has developed an ontology to support agro-environmental modeling for integrated assessments. The CUAHSI ontology contains classes and numerous sub-classes for surface hydrology, subsurface hydrology, water quality, and vegetation.

OMS also will adopt definitions and concepts implicit in the USDA field service center agency master reference data standard for applicable domains, for example, federal information processing standard (FIPS) state and county, conservation practices, major land resource areas, etc.

The initial OMS knowledge base will be used to conceptually underpin the USDA model bases. As OMS matures, the second knowledge base is expected to contribute actual model components to a model base. For example, ecological site state-transition models for rangeland management decision making are best represented semantically in a knowledge base. A model base could contain a mix of semantic and computational knowledge (Figure 10).

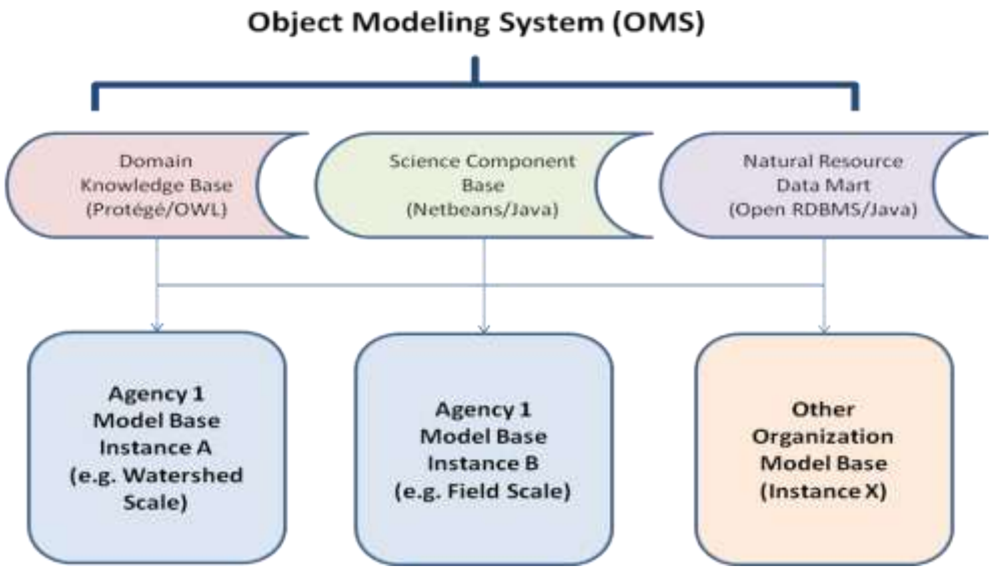

Figure 10. OMS model bases containing a mix of semantic, computational, and data access components

OMS Operations and Management

OMS is maintained and managed at the ARS Agricultural Systems Research Unit (ASRU), located at the Natural Resources Research Center, Fort Collins, Colorado. As stated previously, NRCS has the lead to maintain the framework per Memorandum of Understanding (MOU) activated in February 2008. A copy of the MOU is found in Appendix I.

Current Concept of Operations

The MOU has established the following teams.

- OMS Framework Implementation Team (the OMS Team) – Led by NRCS with ARS and CSU membership and participation. Responsible for the day-to-day maintenance of the framework, including performing system quality assurance and control, deploying and operating model services, adding enhancements, maintaining the component library and knowledge bases, providing training, and keeping system documentation up-to-date. The framework is managed by the NRCS ITC, which assigns a project manager and agency, contractor, and partner resources to the team. The NRCS Chief Information Officer (CIO) within the Deputy Chief for Management supervised the ITC. The responsibilities and skills required for the team are outlined in Appendix III, however, many currently are collateral duties, as the team currently contains five core members and several auxiliary part-time members.

  Within NRCS, coordination across management lines, in particular with the Deputy Chief for Science and Technology, is facilitated through the NRCS Business Tools Council (BTC), which meets monthly. The NRCS annual National IT Project Slate budget allocation process provides funding support for OMS maintenance. The NRCS technical architecture contains OMS as a foundation element. This strategic plan represents the expected direction OMS will take in the future to meet USDA agency business needs, and the vision to this point reflects the perspectives of NRCS and ARS.

- OMS Framework Improvement Team – Currently the OMS Implementation Team performs the functions of this team as outlined in the MOU. Moving forward, the team will be re-constituted as a national team co-chaired by NRCS and ARS to evaluate and prioritize requests for framework enhancements. Membership will include the NRCS CIO and BTC designees, the ARS ASRU Research Leader and National Program Staff (NPS) designees. As OMS expands, so will team membership to include representatives from other partners.
- Model and Decision Support Tool Quality Assurance Team – This team is not yet active. It will be co-chaired by NRCS and ARS, and responsible for a governance process to review, test, and certify OMS models and components for inclusion in the OMS Component Library and for deployment as model services. Membership will include the NRCS CIO and BTC designees, the ARS ASRU Research Leader and National Program Staff (NPS) designees, and as OMS expands, representatives from other partners.

NRCS leverages OMS in its enterprise architecture to develop, manage, and deploy science components in agency business applications, and therefore supports maintenance of the framework, including enhancements to meet agency business needs. OMS partners also will fund or otherwise support improvements to the system, driven by their business needs. For example, a modeling team may need a new OMS feature to support their modeling project. The team either develops and contributes the new feature to the framework, or obtains funding to support building the new feature.

The OMS team actively pursues grant opportunities relating to environmental modeling, particularly those that enable the integration of emerging technologies into the framework.

Currently, OMS Implementation Team members meet every other Tuesday to plan and coordinate workload, assign tasks, resolve issues, and track progress. The team develops and maintains a project plan to track tasks, their dependencies, and resource assignments.

Currently, NRCS and ARS are the two primary USDA users of OMS. Colorado State University is a charter OMS partner through their longstanding research relationship with ARS, and through a Cooperative Ecosystem Studies Unit (CESU) agreement with NRCS. The USDI Geological Survey (USGS) has been an important OMS partner through longstanding research collaboration with ARS. The 65 registered OMS accounts include modelers, scientists, technical specialists, and software developers from ARS, NRCS, CSU, USFS, USGS, EPA, National Park Service (NPS), National Oceanic and Atmospheric Administration (NOAA), and Department of Energy Pacific Northwest Laboratory (DOE-PNL).

The OMS team manages project documentation and product at the collaborative web site http://oms.javaforge.com. The Subversion version control system within the collaboration site contains the OMS source code. The site contains project plans, system documentation, training materials, publications and presentations, meeting minutes, and trackers for system defects and enhancements. The OMS Component Library (http://omslib.javaforge.com) contains model and component metadata descriptions and process for downloading.

Future Concept of Operations

As other USDA agencies and external organizations engage with OMS model development and deployment activity, membership of the three teams likely will adjust through time to reflect their participation. NRCS and ARS will continue to coordinate the maintenance and use of the framework for USDA.

The responsibilities and skills required to support, maintain, operate, and enhance the OMS framework are described in Appendix III. As more agency and organization modelers use the framework, support workload will increase. As OMS models are deployed as services used by business application, resources must be increased to adequately support the run-time and data provisioning platforms. These resources will be funded through interconnectivity agreements with the agencies and organizations consuming OMS model services. Part of the cost will cover resources to support modelers involved with the primary model bases. Access to OMS model services will be less expensive than the infrastructure and operations required supporting a model separately within an organization.

The OMS strategy contains the option of moving to an open source community management model, governed by an independent body (e.g. oms.org or equivalent).

The anticipated OMS lifecycle is 20 years (2008-2027), containing significant upgrades every 3-5 years. The next major upgrade, OMS 3.0, is projected for release in late 2009. The OMS project plan will contain the specific features to be included in the subsequent releases.

Modeling with OMS

As mentioned in previous sections, USDA deploy models to transfer useful technology to the agricultural and natural resource management communities. Model output helps the producer optimize and sustain their operation, the consultant hone their advice and recommendations, the public land manager balance demand on resources, and the agency program manager improve the allocation of technical and financial assistance. Model use by USDA and its partners is expected to become much more widespread than it is today.

Five current and pending modeling initiatives are supported by OMS:

1. Next generation USDA Conservation Effects Assessment Project (CEAP) Model – This ARS Current Research Information System (CRIS) project involves leveraging components of J2Ks (combination of FSU-Jena's J2000 model and SWAT water quality components) and adding components that update the science. This effort establishes the Basin/Watershed Assessment Model Base previously described in OMS Strategic Plan Goal 1. The new model base is expected to be operational for a prototype watershed during 2009. ARS Research Scientist Jim Ascough is the lead modeler.

2. Improved Water Supply Forecasting – This NRCS funded project applies an ensemble streamflow prediction (ESP) method through the integration of the USGS Precipitation and Runoff model (PRMS) in the forecasting process for 600 basins in the western United States (Leavesley et al 2008). The PRMS model maintained in OMS is being deployed to an operational status during 2009. The OMS team and the NRCS Water and Climate Center work jointly on this project. The project could supply the first instance of the Seasonal Natural Resource Forecasting Model Base discussed in OMS Strategic Plan Goal 1. CSU Research Hydrologist George Leavesley is the lead modeler.

3. Next Generation Erosion Model - NRCS has requested ARS to develop a combined updated wind and water erosion model using OMS. The model also will satisfy US Forest Service business requirements. The project will contribute erosion model components to the Farm/Field Level Decision Support Model Base discussed in OMS Strategic Plan Goal 1, and perhaps other core model bases. ARS Research Scientist Dennis Flanagan is the lead modeler.

4. NRCS Engineering Field Tools (EFT) – This business application is written in Java using the Eclipse IDE. The application contains surveying, waterway design, and terrace design. During 2009 science components will be extracted from the application, re-factored in OMS, and deployed as model services on the OMS run-time platform. The project establishes the first instance of the Farm/Field Level Practice Design Model Base. NRCS IT Project Manager Ken Rojas is the lead modeler.

5. Forage Growth and Utilization Model - ARS has previously built the iFarm-FGM (forage growth) model in OMS (Andales et al, 2005). The model has been calibrated for two regions in the western Great Plains. The model incorporates technology from SPUR2 (Simulation of Production and Utilization of Rangeland), simulating above ground biomass production for five functional plant groups (warm season grasses, cool season grasses, legumes, shrubs, and forbs). The model is being calibrated for other regions. Visiting ASRU Research Scientist Samuel Adiko is continuing work with the model. Model components likely will be incorporated at a future date into one or more of the core model bases discussed in OMS Strategic Plan Goal 1.

The contents of the OMS Component Library as of December 31, 2008 are listed in Appendix II. The most up-to-date list is available at http://omslib.javaforge.com.

An emerging business need for OMS model services within USDA involves support for market-based conservation. USDA recently has established an Office of Ecosystem Services and Markets. NRCS has prototyped a Nitrogen Trading Tool that runs against the ARS NLEAP model, and with the CSU Natural Resources Ecology Laboratory deployed a voluntary carbon reporting tool called COMET-VR, which runs against the CENTURY carbon sequestration model. As these efforts and others build out, managers will expect the models to be deployed and managed in a consistent and sustainable manner.

NRCS, ARS, and other USDA agencies are involved with the following models: SWAT, Annualized Agricultural Nonpoint Source Pollution (AnnAGNPS), Rangeland Hydrology and Erosion Model (RHEM) for concentrated flow erosion, Kinematic Runoff and Erosion (KINEROS) for small rangeland watersheds, and Water Induced Soil Erosion, Management, and Natural Systems (WISEMANS) for rangeland hillslopes. These models will be science component sources for OMS model bases and the OMS Component Library.

As discussed previously, modeling in OMS will emphasize creating models and components in Java rather than de-constructing and wrapping legacy model code. With OMS 3.0 modelers will build components as POJOs, independent of the framework. Business need will drive the creation of model bases, containing model instances deployed as services to satisfy the need. Business-oriented model bases contrast with the option of a single monolithic model base at one conceptual end, and the option of a plethora of stand-alone models at the other end. For example, a consultant working with a producer to provide technical assistance and uses several automated tools in the process. A model base built around this business use case is more efficient than creating several separate model bases for each of the tools in the consultant's toolbox. A model base therefore usually will contain more than one model, and often more than one instance of each model if they have been regionalized.

With the emphasis on new Java components and models in OMS, training increases in importance. OMS Strategy Objective 1.4 calls for supporting a core cadre of trained OMS java programmers to further build and maintain the model and component repository. Each model base should be supported by at least two Java developers to ensure continuity. The environmental modeling community finds itself in a transition period with a mix of experienced modelers trained in legacy languages (e.g. Fortran) and the next generation proficient in contemporary languages (e.g. Java, C#). Some modeling projects can expect Java programmers assigned to either convert code written initially in legacy languages or write code from instructions provided by the scientist.

Communication

The OMS Team expects to continue collaborating and interacting with other modeling entities, for example, CUAHSI, Friedrich Schiller University at Jena (FSC-Jena), OpenMI, International Environmental Modeling and Software Society (EIMSS), International Steering Committee on Multimedia Environmental Modeling (ISCMEM), EPA, USGS, CSDMS, among others. The interaction will involve specific collaborations as well as participation in scheduled meetings and conferences. The OMS Team will continue to host training workshops as required.

The OMS web site and splash page will be upgraded to facilitate use of the framework by modelers and model users. To facilitate involvement with modelers outside of USDA, the primary OMS web site will be maintained at http://oms.javaforge.com.

Participation in meetings and conferences, outreach activities, preparation of information materials, etc., will be tracked in the OMS communication plan. Emphasis will be placed on increasing USDA agency involvement with and support to OMS during 2009-2010.

Summary of Key Short-Term OMS Milestones

Description	Target Completion
1. Initial CEAP Model Prototype	Qtr 2 2009
2. USDA Enterprise Architecture Documentation for OMS	Qtr 3 2009
3. Detailed data provisioning architecture	Qtr 3 2009
4. Data provisioning support plan and approval	Qtr 3 2009
5. USDA model base definition and approval	Qtr 3 2009
6. Improved NRCS Water Supply Forecasting operational	Qtr 3 2009
7. Modifications to support non-invasive component development (OMS 3.0)	Qtr 4 2009
8. Cloud computing run-time platform and multi-threading operational	Qtr 4 2009
9. Prototype OMS knowledge base	Qtr 4 2009

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Appendix I – Memorandum of Understanding Between the USDA Agricultural Research Service and Natural Resources Conservation Service

AGREEMENT TO TRANSFER
OBJECT MODELING SYSTEM FRAMEWORK
FROM
UNITED STATES DEPARTMENT OF AGRICULTURE,
AGRICULTURAL RESEARCH SERVICE
TO
NATURAL RESOURCES CONSERVATION SERVICE

WHEREAS, the Agricultural Research Service (ARS) developed the Object Modeling System (OMS) Framework in cooperation with the Natural Resources Conservation Service (NRCS) to streamline the development and delivery of science-based integrated agricultural system models and decision support tools; and

WHEREAS, ARS and NRCS understand this Agreement is limited to transferring the OMS Framework to NRCS and does not include transfer of any actual science-based models or decision support tools; and

WHEREAS, an OMS Framework will bring value to both ARS and NRCS by allowing new science-based models and decision support tools to be developed more quickly and make them easier to maintain, while certifying their quality;

NOW, THEREFORE, ARS and NRCS agree as follows:

<u>Article 1</u>

<u>Background</u>

OMS Framework was developed through a comprehensive ARS led effort in partnership with the NRCS, the United States Geological Survey (USGS), and university collaborators. OMS Framework helps streamline the development and delivery of science-based integrated agricultural system models and decision support tools. Such models and tools developed by ARS support conservation planning, conservation practice design, conservation effects assessment, attaining sustainable agricultural systems, and ongoing research in these areas for USDA customers and stakeholders.

<u>Article 2</u>

<u>OMS Framework Functionalities</u>

ARS and NRCS agree the functionality of the OMS Framework is limited to that functionality specifically listed in Article 2.

Functionality:

a. A *Component Builder* user interface for developing science components in Java language. It also allows the adaptation of legacy components written in the other programming languages. Components are stored and maintained in the central USDA component library.

b. Visual integration of components into complex simulation models using a *model builder*.

c. *Application Programming Interface API* that allows easy access to temporal and spatial data sets such as *files, databases, and GIS* data sets.

d. *Model Calibration and Execution Management*. A framework for model parameter calibration that implements the Shuffled Complex Evolution (SCE) algorithm is integrated into the OMS Framework. Other methods for execution of models and Ensemble Stream-flow Prediction are provided.

e. *Data Analysis* tools, and plotting capabilities. Various graphical and analysis tools are available that can be used to relate input and output data of various model runs.

f. A USDA collaboration system that allows remote and decentralized collaborated development of models and tools by different scientists and agencies. It manages a *Library of Components and Models* that can be shared among developers.

g. OMS is designed to allow the execution of models in a *Service Oriented Architecture* by allowing the setup of Web-Services to remotely execute models.

Article 3

NRCS OMS Framework Implementation Team

NRCS shall have the responsibility for staffing the OMS Framework Implementation Team. ARS may participate in this team as needed.

Article 4

Future OMS Framework Development

ARS and NRCS shall establish an ARS/NRCS OMS Framework Improvement Team. The mission of the ARS/NRCS OMS Framework Improvement Team is to:

a. Implement the Framework recommendations of the OMS Framework expert panel as appropriate.

b. Periodically review the OMS Framework and update, revise, or expand its functionality as appropriate.

Article 5

Framework Evaluation

At the OMS Workshop held in Fort Collins, CO September 5-7, 2007, an independent expert panel was selected to review the OMS Framework functionality. This panel will issue a report on the functionality of the OMS framework (expected October 19, 2007) as well as make recommendations as to future improvements to the framework. ARS and NRCS agree that any recommendations will be considered by the ARS/NRCS OMS Framework Improvement Team, listed in Article 4, at a mutually agreed to time. ARS and NRCS further agree these recommendations will not delay the transfer of the OMS Framework to NRCS.

Article 6

Model and Decision Support Tool Quality Assurance Team

ARS and NRCS shall establish a Quality Assurance Team whose mission is to develop, revise, and maintain methodology for reviewing, testing, and determining the acceptability of a software module to be included in the OMS Framework library. The Quality Assurance Team shall develop within sixty (60) days of final signature to this Agreement detailed acceptability procedures that will be used to train scientists. The Quality Assurance Team will ensure the acceptability process includes the following:

a. The quality assurance methodology is based upon industry-accepted software certification practices.

b. The quality assurance methodology is unbiased in its application and interpretation and is documented version by version so that it may be defended at any time in the future and in the context of specific modules to which the various versions were applied.

c. The quality assurance methodology shall include comprehensive record-keeping and reporting components so that any question from any source, including consumers, may be answered at a future time regarding the circumstances and conditions surrounding the acceptability of any module.

d. The quality assurance methodology includes a means of attaching a permanent identifier to a module that has been considered for acceptance. The means of identification will be as secure as possible given available technology.

e. The quality assurance methodology is independently reviewed by qualified reviewers. The methodology is re-reviewed when substantial changes are made.

f. The quality assurance methodology should allow a decision to accept or not accept within ten (10) business days of beginning the process for a module.

Article 7

Model and Decision Support Tool Certification

NRCS has the responsibility for any internal or external software and/or source code certification.

Article 8

OMS Framework Maintenance

NRCS has the responsibility for maintenance of the OMS Framework. ARS shall provide technical assistance as needed. This assistance shall include assisting NRSC in fixing any system bugs.

Article 9

Amendments

If either party desires a modification in this Agreement, the parties shall confer in good faith to determine the desirability of such modification. Such modification shall not be effective until a written amendment is signed by both Parties.

Article 10

Termination

Either party may unilaterally terminate this entire Agreement at any time by giving the other party written notice not less than sixty (60) calendar days prior to the desired termination date.

Article 11

Entire Agreement

This Agreement constitutes the entire agreement between the NRCS and ARS and supersedes all prior agreements and understandings between them with respect to its subject matter. Any representation, promise, or condition in connection with such subject matter which is not incorporated in this Agreement shall not be binding upon either party.

ACCEPTED FOR ARS:

s/Dr. Edward Knipling, Administrator, ARS

February 26, 2008

ACCEPTED FOR NRCS:

s/Arlen Lancaster, Chief, NRCS

February 26, 2008

Appendix II – OMS Component Library

The science components in the OMS Component Library as of January 1, 2009 are listed in this appendix by the five current modeling effort sources. The OMS strategy is to move from individual models to model bases, and the components will become more loosely coupled, designed and documented to optimize re-use. The primary developers/authors of the components currently in the library are Olaf David, Jim Ascough, George Leavesley, Peter Krause, Ken Rojas, Allan Andales, Wes Lloyd, and Candice Batts.

Component Source				
PRMS	**WWEM**	**J2000s**	**Sparam**	**iFarm-FGM**
Climate				
		ClimatologicalVariables	ReadAtmsFile WindUtil	
Precipitation				
Interception Precip Preciplacres PrecipKrig Snowcomp	BreakpointRZStormProvider ReadRZWQMbreakpointStorm SetupTwentyFourHourLoop SumStormInfo SumTwentyFourHourLoop Hyd2ero	RainCorrectionRichter J2KProcessInterception CalcRainSnowParts J2KProcessSnow	Snowmelt	
Temperature				
Temp1sta XyzDist XyzDistSoltsta				
Solar Radiation				
Ccsolrad366 CcsolradRadpl Ddsoilrad Ddsolrad366 DdsolradHru DdsolradOrig DdsolradRadpl DdsolradXyzSoltsta Soltab Soltab366		CalcDailyNetRadiation CalcDailyNetRadiationSolrad CalcDailySolarRadiation CalcExtraterrRadiation CalcIDWeights CalcNidwWeights Regionalization Regionalization1 DailySolarRadiationCalculationMethods	CalcAlbedo CalcNetRad	

Soltab366Hru SoltabHru SoltabOrig SoltabRadpl		GKConversion HourlySolarRadiationCalculationMethods SolarRadiationCalculationMethods		
Humidity				
		CalcAbsoluteHumidity CalcRelativeHumidity		
Evapotranspiration				
PotetHamon PotetJh	PotEvapTranspiration	PenmanMonteith RefEST	AtmsUtil Evaporation SWPotentialET Transpiration	
Infiltration				
GrnamptInfil	GreenAmptInfiltration DailyRZMetProvider		CalcDepthWtFrnt CalcInfLyrWtr CollapseInflLyrs InitInflLyr SatInfiltration UnsatInfiltration	
Surface Run-Off				
KroutChan KroutOfpl DebrisFlow SrunoffSmidx	Kinwave Dofalvel	J2KProcessReachRouting J2KProcessRouting		
Soil Moisture				
Smbal Symballacres	BCHyraulicFunctions BCParamint DarcyWaterRedistribution Darcy Driver DarcyReport	InitJ2KProcessLumpedSoilWaterStates CalcAreaWeight J2KProcessLumpedSoilWater	CalcMatricPot CalcSoilWtr Redistribution	
Groundwater				
Gwflow Ssflow		InitJ2KProcessGroudWater J2KProcessGroundWater StandardGroundWaterReader		

Streamflow				
Strmflow Strmflowlacres StrmflowLkiso StrmflowOld StrmflowSt StrmflowSubbasin Subbasin				
Soil Properties				
	DefaultSoilProperties	CalcSlopeAspectCorrectionFactor StandardSoilReader	CalcRandRoughTill CalcRndRghRecons MacroporeAdj Reconsolidation SoilProp CalcResist CalcRootFrac CalcTopProp InitSoilLyr ReadSoilFile SoilHydLyr	
Erosion and Deposition				
	Param Profil Route Sedout Sloss Xinfo Winderode			
Crop/Plant Growth				
		J2KSNDormancy J2KSNLMArable J2KSNTillage		

Water Balance				
			WatBal WatBalUtil	
Nutrient Fate/Transport				
Pesticide Fate/Transport				
Model Management				
Basin Basinlhacres BasinSum Input Obs ObsDaily Obslhacres ObsOld ObsOld2 Ouput SubBasin	Cross Eprint	CalcAreaWeight WeightedSumAggregator SumAggregator CalcLatLong CalcLanduseStateVars FlowConverter StandardEntityReader StandardLUReader TSDataReader TSDataUpdater MathematicalCalculations Regression UTMConversion	ResetDailyValues WriteOutput	

Appendix III – OMS Framework and Modeling Project Roles and Responsibilities

The OMS framework and associated modeling projects require staffing with appropriate knowledge, skills, and abilities. The following roles and responsibilities are necessary to support USDA agro-environmental modeling efforts. They are presented in an idealized manner, recognizing that level of effort and project size may combine roles into fewer positions with collateral duties, also recognizing multiple proficiencies in a single position carries a premium.

<u>OMS Framework Implementation Team</u>

Project Manager

Certified Information Technology Project Management Professional (PMP); experience with agro-environmental model development; working knowledge of USDA agency business needs.

Lead OMS Architect

Senior level computer scientist; proficient in contemporary Java, agro-environmental model development, application architectures, SOA, cloud computing, and knowledge bases.

Information Technology Specialist – Modeling Platform Developer

Proficient in contemporary Java; maintains and enhances the OMS API and features that support model and component development.

Information Technology Specialist – Model Run-Time Platform Developer

Proficient in contemporary Java, SOA, and cloud computing; maintains and enhances the OMS API and features that support the deployment of OMS model services on the production platform.

Information Technology Specialist – Data Provisioning Platform Developer

Proficient in data modeling, SQL, ETL tools, object-relational mapping, contemporary programming languages and scripting, and SOA; maintains and enhances the OMS API and features that support provisioning of data and access services for agro-environmental models.

Information Technology Specialist – Knowledge Base Platform Developer

Proficient in semantic web technologies, Protégé-OWL, and knowledge management methods; maintains and enhances the OMS API and features that support managing model and component metadata, defining and maintaining core agro-environmental concepts, and integrating conceptual and computational knowledge in models.

Information Technology Specialist – Quality Assurance and Control

Proficiency in contemporary Java, Protégé-OWL, configuration management, and testing methods; ensures OMS models and components comply with development, validation, and certification processes and standards; reviews and rates OMS components for re-usability; maintains the OMS Component Library and Model/Component Knowledge Base.

OMS Training and Communication Specialist

Proficient in the use of the OMS framework, training methods, and marketing strategies; trains OMS modelers, develops training materials, and develops marketing and communication products.

Agro-Environmental Modeling Project Team

Project Manager

Certified Information Technology Project Management Professional (PMP); experience with agro-environmental model development; working knowledge of USDA agency business needs.

Lead Scientist

Scientist responsible for the technology to be incorporated into the model base; leads a team of scientists contributing technology to the model base; proficiency in Java desirable, but not required; coordinates model calibration and validation; certifies the model and associated components.

Model Base Architect

Proficiency in modeling techniques and contemporary Java; develops the model base design and oversees model and component programming; supports lead scientist in model calibration and validation.

IT Specialist – Developer

Proficiency in contemporary Java; develops and unit tests model and component code; developer backup desired.

Model Calibration Specialist

Proficiency in model calibration techniques and the scientific content of the model ; calibrates models for use in geographic regions; may be adjunct members of a modeling project team, located in the regions where the model base will be used.

Agro-Environmental Model Base Data Provisioning and Calibration Support Team

Project Manager

Certified Information Technology Project Management Professional (PMP); experience with agro-environmental model development; working knowledge of USDA agency business needs.

Lead Data Architect

Proficiency in data modeling, relational databases, SQL, SOA, and knowledge bases; develops overall data provisioning architecture, data mart designs, metadata management strategies, and data access service designs.

Database Administrator

Proficiency in database performance monitoring and tuning techniques; ensures that model access to data is optimized.

Information Technology Specialist – Data Access Services Developer

Proficiency in object relational mapping, SOA, contemporary programming languages and scripting; develops data access services for approved model bases.

Data Steward

Proficiency in data administration methods and thorough knowledge of the data and associated business requirements; ensures that datasets are complete and validated for model use;

probably located in the regions where the model base will be used and working closely with the model calibration specialist.

Model Calibration Specialist

Proficiency in model calibration techniques and the scientific content of the model ; calibrates models for use in geographic regions; may be adjunct members of a modeling project team, located in the regions where the model base will be used.

Appendix IV – OMS Component Metadata Annotation Standard

The following are component library Java annotations for OMS modeling components:

Annotation name	Sub Attribute	Datatype	Description
Author	name	String	Component author's name
Author	email	String	Component author's email address
Author	organization	String	Component author's organization
Comp	-	-	This annotation marks a Java class as an OMS component so the component library is able to identify it as a OMS component, and not just a Java class
Date	value	String	Date of component publication. populated by SVN
Description	format	String	Describes the format type of the description. Default is HTML
Description	value	String	Component description
DevStatus	value	enum Type	Used to indicate the maturity of the component. Values: DRAFT, TESTED, VALIDATED, CERTIFIED
Keywords	value	String	List of keywords describing the component
License	value	String	License information if any
References	value	String[]	List of literature references
Revision	value	String	The subversion file revision number. populated by SVN
SourceInfo	value	String	URL pointing to the source code file under subversion
VersionInfo	value	String	Populated by SVN, indicates the subversion version information.

Component attributes that are automatically derived (not provided by the developer with Java annotations):

Attribute Name	Description
Component Name	Java class name of the component
Canonical Name	Complete package name of the component

Other annotations used in OMS for describing component attributes:

Annotation name	Sub Attribute	Datatype	Description
Access	value	enum AccessType	Values: READ, WRITE, READWRITE
Attr	-	-	Marks a data field as an OMS attribute
Constraint	min	double	Not a repository annotation. Used to describe min values of OMS model attributes
Constraint	max	double	Not a repository annotation. Used to describe max values of OMS model attributes
Default	value	String	Used to provide a default value for an OMS attribute
Dimension	value	String	Describes the attribute dimension (L, H, W, etc.)
JNIArgs	value	String[]	
Role	value	String	Describes the role of the model attribute???
Summary	value	String	Description of OMS component attribute
Unit	value	String	Units of the OMS Attribute (in, cm, l, oz, etc.)

In OMS, component library annotations appear on individual separate lines at the top of the Java source file for example:

```
@Description("this is the description")
@Author(name="Olaf David", email="olaf.david@ars.usda.gov")
@Keywords("CEAP, J2000")
```

By default the "value" sub attribute name is assumed. You only are required to specify the sub attribute name when it is something besides "value".

The annotations for describing component attributes are also scanned/parsed by the repository and added to the component's description when published. Those these attributes were not developed solely for descriptive purposes in the repository.